Determinants of Survival among HIV-Infected Chronic Dialysis Patients

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Abstract. Over 100 HIV-infected patients have initiated chronic dialysis at San Francisco General Hospital (SFGH) since 1985. This study employed retrospective analysis to identify determinants of and trends in survival among HIV-infected patients who have initiated chronic dialysis at SFGH from January 1, 1985 to November 1, 2002 (n = 115). Cohort patient survival was compared with survival after an AIDS-opportunistic illness in all HIV-infected patients in San Francisco during the study period. Higher CD4 count (hazard ratio [HR], 0.86 per 50 cells/mm³ increase; 95% confidence interval [CI], 0.80 to 0.93) and serum albumin (HR, 0.53 per 1 g/dl increase; CI, 0.36 to 0.78) at initiation of dialysis were strongly associated with lower mortality. Survival for those initiating dialysis during the era of highly active antiretroviral therapy (HAART) was 16.1 mo versus 9.4 mo for those initiating dialysis before this time, but this difference was not statistically significant. In adjusted analysis, only a non-statistically significant trend toward improved survival during the HAART era was noted (HR, 0.59; CI, 0.34 to 1.04). By comparison, survival for all HIV-infected patients after an AIDS-opportunistic illness in San Francisco increased from 16 mo in 1994 to 81 mo in 1996. The dramatic improvement in survival that has occurred since the mid-1990s for patients with HIV appears to be greatly attenuated in the sub-group undergoing dialysis. Although this may partly reflect confounding by race, injection drug use and HCV co-infection, future attempts to improve survival among HIV-infected dialysis patients should focus on barriers to the effective use of HAART in this group.

Despite improvements in the care of HIV-infected patients since the mid-1990s (1–4), the number of incident patients with end-stage renal disease (ESRD) due to AIDS nephropathy (also known as HIV-associated nephropathy [HIVAN]) reported to the United States Renal Data System (USRDS) has been increasing (5). Furthermore, despite several recent reports of improved survival in ESRD patients treated with highly active anti-retroviral therapy (HAART) (6–8), those with HIVAN still represent one of the highest mortality groups among ESRD patients, second only to persons with ESRD due to hepatorenal syndrome or nepheliasis (9–11).

We retrospectively reviewed the medical records of all 115 HIV-infected patients who have initiated chronic dialysis at San Francisco General Hospital (SFGH) since 1985. Our objectives were (1) to identify factors associated with improved survival in these patients and (2) to determine whether survival has improved during the HAART era (1995 onwards). To place our results in context, we compared changes in survival during the study period for HIV-infected ESRD patients with survival for all HIV-infected patients after an AIDS-opportunistic illness in the San Francisco area.

Materials and Methods

We reviewed the medical records of all HIV-infected patients who initiated outpatient dialysis at SFGH from January 1, 1985 through November 1, 2002. We included all patients who initiated chronic dialysis at SFGH during the study period and were diagnosed with HIV either before or after initiation of dialysis. Diagnosis of HIV before the introduction of HIV testing was based on AIDS case definitions in place at the time (12,13). We ascertained baseline demographic information (age, race, and gender), laboratory information (CD4 count, albumin, hematocrit, HIV viral load [detectable versus undetectable], presence of Hepatitis C antibody [HCV] and Hepatitis B surface antigen [HbsAg]), co-morbidity data (body mass index and history of diabetes), and the results of renal biopsy (if performed) by retrospective review of the medical record.

We also collected data on HIV-related variables from the medical record. These included date of initial HIV diagnosis, history of prior opportunistic illness as defined elsewhere (12), mode of transmission (injection drug use versus other), and whether patients were taking HAART at the time of initial dialysis. The standard definition of HAART is the use of three antiretroviral drugs including a protease inhibitor. The use of HAART and the staging of HIV with viral load only became the standard of care after 1995. Therefore this information was available for only a subgroup of cohort patients.

Finally, we collected dialysis-related information such as the initial dialysis modality (peritoneal dialysis versus hemodialysis) and date of initial dialysis for each patient. We considered patients to be perito-
neal dialysis patients if they were initiated on peritoneal dialysis within 60 d of the onset of ESRD.

We followed patients from initiation of dialysis to date of death, transfer to a dialysis unit outside the state, renal transplantation (two patients), or to the end of the study period on November 1, 2002. The Transpacific Renal Network provided death data for all patients who died during the study period.

To place our results in context, we compared survival in cohort patients with survival after an AIDS-opportunistic illness (13) among all HIV-infected patients in San Francisco — a population recognized to have relatively poor survival. We obtained these data from the San Francisco Department of Public Health. AIDS cases were reported to the Department of Public Health through active surveillance, passive surveillance, and review of death certificates (14). We compared causes of death in cohort patients to causes of death for non–HIV-infected ESRD patients at SFGH during the study period. These data were provided by Network 17.

**Statistical Analyses**

We describe cohort patient characteristics in terms of mean values for normally distributed continuous variables and percentages for categorical variables. We used survival analysis to measure the association of patient characteristics with time from dialysis initiation to death. We censored patients at the time of loss to follow-up, renal transplantation (two patients), or on November 1, 2002. We performed univariate survival analyses to measure the association of each baseline characteristic with the outcome using Cox regression.

Because more detailed information was available for patients initiating dialysis during the HAART era (i.e., HCV, HIV viral load, HAART therapy, angiotensin-converting enzyme (ACE) inhibitor use, and urine protein excretion), we conducted two separate multivariate survival analyses. First, we measured the association of variables available throughout the study period (i.e., all variables missing < 10% of data in Table 2 footnote) with survival among all cohort patients (n = 115). We then measured factors associated with survival among the subgroup of patients initiating dialysis during the HAART era (n = 57). This allowed us to measure the association of several variables for which data were not available for most patients initiating dialysis before the HAART era (i.e., HCV, HIV viral load, HAART therapy, ACE inhibitor use, and urine protein excretion).

We conducted survival analysis for the whole group using a forward stepwise Cox proportional hazard model to identify those variables that were most strongly associated with the outcome. For multivariate analysis, we entered CD4 count as a continuous rather than a categorical variable. Only those variables that showed a statistically significant association with the outcome on multivariate model building were retained in the model. Hence the final model is adjusted only for those variables included rather than for all candidate variables.

We handled missing data for variables included in multivariate model building for the whole group (i.e., those missing < 10% of values) as follows: for categorical variables, we included a separate missing indicator variable in the model. For continuous variables that were missing data, we assigned a mean value to missing observations and also included a separate missing indicator variable in the model. This approach allowed all observations to be used in estimating the effects of variables that were not missing, but inclusion of the missing indicator variable ensured that imputation of missing values had no influence on that variable’s estimated effects.

In subgroup analyses of patients initiating dialysis during the HAART era, we measured the respective associations of each variable available only for this patient group (i.e., HCV, HIV viral load, HAART therapy, ACE inhibitor use, and urine protein excretion) with survival adjusted for those variables associated with the outcome in stepwise multivariate analysis described above. We tested each multivariate model for violation of the proportional hazard assumption using standard residual-based methods.

To understand trends in survival over the study period, we compared baseline characteristics of patients initiating dialysis before versus during the HAART era. We compared normally distributed continuous variables using the t test and categorical variables using the χ² test. We compared overall survival during the HAART versus pre-HAART eras using the log-rank test. We then compared our findings with survival for all HIV-infected patients with a history of AIDS-opportunistic illness in the San Francisco area over the same period. We used a Cox proportional hazard model to measure the association of initiation of dialysis during the HAART era versus before this time with survival after adjustment both for differences in patient characteristics between the two periods and for all variables associated with survival in the stepwise model described above.

**Results**

A total of 115 HIV-infected patients have been initiated on chronic dialysis at our institution since 1985. Table 1 (column 1) shows the characteristics of the study population. Renal biopsy results were available for only 32 patients. The most common diagnosis on renal pathology was HIVAN (66%) with membranoproliferative glomerulonephritis (MPGN) a distant second (16%). There were no cases of HIVAN among the three white patients biopsied.

Several variables (urine protein excretion, HAART use, HCV, HIV viral load, and ACE inhibitor use) were measured in few, if any, patients initiating dialysis before 1995. We therefore present these variables only for the subset of patients initiating dialysis after this time. HIV RNA was measured in only 44 patients at initiation of dialysis. Among these, levels were undetectable in eight patients. In the remaining 36 patients, levels of HIV RNA ranged from 102 to ≥ 500,000 copies/ml, with a median value of 27,896 copies/ml.

Survival data were available for all patients. As of November 1, 2002, almost 80% of the cohort had died (91 patients). Follow-up time ranged from 12 d to 143.5 mo. Overall survival after starting dialysis was 46% at 1 yr, 30% at 2 yr, 23% at 3 yr, 10% at 4 yr, and 9% at 5 yr. Ten patients survived longer than 5 yr; the baseline characteristics of these ten patients included all but two with CD4 counts > 200 cells/mm³, only two with a history of injection drug use, and all but one with a serum albumin > 3.0 g/dl at the time of initiation of dialysis.

Median survival for the whole group was 12.3 mo. Median survival was much longer for patients with CD4 counts above 200 cells/mm³ (33.4 mo) compared with those with CD4 counts ≤ 200 cells/mm³ (7.7 mo). Median survival was markedly lower for patients with serum albumin ≤ 3 g/dl (9.4 mo) compared with those with serum albumin > 3 g/dl (30.1 mo). On univariate analysis, female gender, low serum albumin, hemodialysis as initial modality, low CD4 count, and history of AIDS-opportunistic illness were all associated with poor survival in this patient group as shown in Table 2. In multivariate analysis, serum albumin and CD4 count were independently associated with the outcome (Table 3). We found no evidence
Table 1. Patient characteristics by date of initial dialysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>All Patients</th>
<th>Pre-HAART Era</th>
<th>HAART Era</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>41.7 ± 8.6</td>
<td>39.6 ± 7.5</td>
<td>43.7 ± 9.2</td>
<td>0.006</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>87%</td>
<td>83%</td>
<td>92%</td>
<td>0.16</td>
</tr>
<tr>
<td>White</td>
<td>7%</td>
<td>11%</td>
<td>4%</td>
<td>0.14</td>
</tr>
<tr>
<td>Latino</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>0.98</td>
</tr>
<tr>
<td>Native-American</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
<td>0.31</td>
</tr>
<tr>
<td>Male gender</td>
<td>87%</td>
<td>95%</td>
<td>79%</td>
<td>0.014</td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>26.5 ± 5.8</td>
<td>24.1 ± 4.6</td>
<td>28.8 ± 5.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Albumin (g/dl)</td>
<td>2.7 ± 0.7</td>
<td>2.8 ± 0.7</td>
<td>2.7 ± 0.7</td>
<td>0.41</td>
</tr>
<tr>
<td>Mean BMI (kg/m²)</td>
<td>21.9 ± 4.1</td>
<td>21.2 ± 3.0</td>
<td>22.6 ± 4.8</td>
<td>0.029</td>
</tr>
<tr>
<td>Percent diabetics</td>
<td>4%</td>
<td>2%</td>
<td>5%</td>
<td>0.32</td>
</tr>
<tr>
<td>Peritoneal dialysis</td>
<td>17%</td>
<td>25%</td>
<td>10%</td>
<td>0.044</td>
</tr>
<tr>
<td>Injection drug use</td>
<td>63%</td>
<td>59%</td>
<td>68%</td>
<td>0.33</td>
</tr>
<tr>
<td>HBV</td>
<td>4%</td>
<td>2%</td>
<td>5%</td>
<td>0.32</td>
</tr>
<tr>
<td>CD4 count ≤ 200 cells/mm³</td>
<td>53%</td>
<td>55%</td>
<td>51%</td>
<td>0.68</td>
</tr>
<tr>
<td>CD4 count (cells/mm³)</td>
<td>217 ± 198</td>
<td>217 ± 210</td>
<td>217 ± 188</td>
<td>0.49</td>
</tr>
<tr>
<td>AIDS-OI</td>
<td>45%</td>
<td>58%</td>
<td>33%</td>
<td>0.007</td>
</tr>
<tr>
<td>Proteinuria (g/24 h)</td>
<td></td>
<td></td>
<td>8.4 ± 5.6</td>
<td></td>
</tr>
<tr>
<td>HAART at onset of ESRD</td>
<td>33%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCV</td>
<td>68%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HIV viral load detectable</td>
<td>82%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACE inhibitor use</td>
<td>17%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* P values are for differences between those initiating dialysis before versus during the HAART era. Categorical variables are compared using a χ² test, and continuous predictors are compared using a t test. BMI, body mass index; HCV, hepatitis C infection; HBV, Hepatitis B infection; AIDS-OI, history of AIDS-opportunistic illness; HAART, highly active anti-retroviral therapy; ESRD, end-stage renal disease.

b Data not available for most patients initiating dialysis before 1995.

for an interaction between these two variables (P = 0.86) and no violation of the proportional hazard assumption was detected (P = 0.42).

For patients initiating dialysis during the HAART era, after adjusting for albumin and CD4 count, we found no statistically significant associations for the following variables with mortality. The number of patients included in each regression analysis is indicated in each case: HAART use at initiation of dialysis (hazard ratio [HR], 0.99; 95% confidence interval [CI], 0.48 to 2.04; P = 0.97; n = 57), viral load (detectable versus undetectable; HR, 1.93; CI, 0.65 to 5.69; P = 0.24; n = 44), urine protein (HR, 1.03 per 1 g/24 h increase; CI, 0.95 to 1.10; P = 0.60; n = 43), ACE inhibitor use at initiation of dialysis (HR, 1.54; CI, 0.53 to 4.51; P = 0.80; n = 48), and HCV positivity (HR, 1.36; CI, 0.60 to 3.06; P = 0.74; n = 53).

Although median survival was longer for those initiating dialysis before this time (9.4 mo), this difference did not reach statistical significance. Table 1 compares the characteristics of patients initiating dialysis during versus before the HAART era. Patients who initiated dialysis before the HAART era were on average younger and more likely to be male compared with those initiating dialysis after this time. This group also had a lower average hematocrit (24.1% versus 28.8%) and lower mean body mass index (BMI) (21.2 kg/m² versus 22.6) at initiation of dialysis. Finally, patients initiating dialysis before the HAART era were more likely to choose peritoneal dialysis as their initial modality and to present with a history of AIDS-opportunistic illness. We found no statistically significant differences between patients initiating dialysis during versus before the HAART era in initial CD4 count (either in the mean value or in the percentage of patients with a CD4 count ≤ 200 cells/mm³), serum albumin, percent injection drug users, percent with diabetes, or racial composition. On multivariate analysis, there was a non-statistically significant trend toward improved survival for patients initiating dialysis during the HAART era after adjusting for albumin and CD4 count in addition to all variables that differed between patients initiating dialysis before versus during the HAART era (HR, 0.59; CI, 0.34 to 1.04; P = 0.066).

Table 4 shows data from the San Francisco Department of Public Health for survival after an AIDS-opportunistic illness in all HIV-infected patients in San Francisco as of November 1, 2002. Of note, median survival increased fivefold between...
1994 and 1996 (from 16 to 81 mo). In fact, among the subgroup of patients with a CD4 count ≤ 200 cells/mm³, median survival cannot currently be calculated due to prolonged survival in this group (personal communication: Hsu L, San Francisco Department of Public Health, 2002). Compared with all HIV-infected patients with opportunistic illness in San Francisco during the study period, HIV-infected ESRD patients had a higher rate of injection drug use (50.4% versus 23%), were less likely to be homosexual men (32% versus 74%), and were more likely to be African American (86% versus 14%) (personal communication: Hsu L, San Francisco Department of Public Health, 2002). Data provided to us by Network 17 (personal communication: Susan Tanner, Network 17, October 2002) indicate that the major causes of death among cohort patients were infection (54%), drug overdose or dialysis noncompliance (16%), and cachexia (9%), with cardiovascular causes accounting for less than 5% of all deaths. By comparison, cardiovascular disease (32%) and infection (22%) were the most common causes of death among the group of non-HIV-infected ESRD patients undergoing chronic dialysis at the SFGH from 1991 to 2002 (n = 186).

### Discussion

Several recent studies have reported modest improvements in survival in HIV-infected ESRD patients since the mid-1990s (Table 5). However, despite improvements in ESRD and HIV care since this time, these studies show that survival of HIV-infected ESRD patients is still extremely low relative to HIV-infected patients without ESRD. Our data point to a widening gap in survival between HIV-infected patients with ESRD and those without ESRD (15) in San Francisco during the HAART era.

Persistent differences in survival between ESRD and non-ESRD patients with HIV in San Francisco may partly reflect a higher prevalence of known risk factors for mortality in HIV-infected patients with ESRD compared with those without ESRD. Cohort patients were more likely than HIV-infected patients with a history of AIDS-opportunistic illness in San Francisco to be African American and to be injection drug

### Table 2. Univariate Cox survival analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per 10-yr increase)</td>
<td>1.02</td>
<td>0.78 to 1.31</td>
<td>0.87</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>1.00</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>White</td>
<td>0.71</td>
<td>0.28 to 1.75</td>
<td>0.45</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.82</td>
<td>0.79 to 4.18</td>
<td>0.16</td>
</tr>
<tr>
<td>Native-American</td>
<td>2.00</td>
<td>0.27 to 14.58</td>
<td>0.69</td>
</tr>
<tr>
<td>Male gender</td>
<td>0.50</td>
<td>0.26 to 0.96</td>
<td>0.036</td>
</tr>
<tr>
<td>Hematocrit (per 5% increase)(^b)</td>
<td>0.84</td>
<td>0.69 to 1.01</td>
<td>0.057</td>
</tr>
<tr>
<td>Albumin (per 1 g/dl increase)(^b)</td>
<td>0.39</td>
<td>0.27 to 0.56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BMI (per 1 kg/m² increase)(^b)</td>
<td>0.95</td>
<td>0.90 to 1.02</td>
<td>0.14</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.35</td>
<td>0.09 to 1.42</td>
<td>0.14</td>
</tr>
<tr>
<td>Initiation of dialysis 1995+</td>
<td>0.75</td>
<td>0.49 to 1.15</td>
<td>0.19</td>
</tr>
<tr>
<td>Peritoneal dialysis as initial modality</td>
<td>0.55</td>
<td>0.31 to 0.97</td>
<td>0.038</td>
</tr>
<tr>
<td>Injection drug use(^b)</td>
<td>1.40</td>
<td>0.88 to 2.23</td>
<td>0.15</td>
</tr>
<tr>
<td>HCV(^c)</td>
<td>1.13</td>
<td>0.53 to 2.37</td>
<td>0.31</td>
</tr>
<tr>
<td>HBV</td>
<td>0.92</td>
<td>0.28 to 2.92</td>
<td>0.88</td>
</tr>
<tr>
<td>CD4 count ≤ 200 cells/mm³(^b)</td>
<td>3.22</td>
<td>2.03 to 5.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CD4 count (cells/mm³)(^b)</td>
<td>0.82</td>
<td>0.76 to 0.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>AIDS-OI</td>
<td>2.33</td>
<td>1.53 to 3.55</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HIV viral load (detectable versus undetectable)(^c)</td>
<td>1.83</td>
<td>0.63 to 5.31</td>
<td>0.27</td>
</tr>
<tr>
<td>HAART at onset of ESRD(^d)</td>
<td>0.89</td>
<td>0.44 to 1.83</td>
<td>0.77</td>
</tr>
<tr>
<td>Proteinuria (per 1 g/24 h increase)(^c)</td>
<td>1.02</td>
<td>0.95 to 1.09</td>
<td>0.54</td>
</tr>
<tr>
<td>ACE use at onset of ESRD(^d)</td>
<td>1.19</td>
<td>0.45 to 3.15</td>
<td>0.36</td>
</tr>
</tbody>
</table>

\(^a\) CI, confidence interval; BMI, body mass index; HCV, Hepatitis C infection; HBV, Hepatitis B infection; HIVAN, HIV-associated nephropathy; HAART, highly active anti-retroviral therapy; ESRD, end-stage renal disease; AIDS-OI, history of AIDS-opportunistic illness.

\(^b\) Missing data but <10% values.

\(^c\) Data not available for most patients initiating dialysis before 1995.

### Table 3. Stepwise multivariate Cox survival analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Hazard Ratio</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD4 count (per 50 cells/mm³)</td>
<td>0.86</td>
<td>0.80 to 0.93</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Albumin (per 1 g/dl)</td>
<td>0.53</td>
<td>0.36 to 0.78</td>
<td>0.001</td>
</tr>
</tbody>
</table>
users — both recognized risk factors for death in non-ESRD HIV-infected patients (16). In addition, there was a high prevalence of HCV co-infection among cohort patients who were tested.

The dramatic improvements in survival seen for all HIV-infected patients after an AIDS-opportunistic illness in San Francisco since 1995 clearly reflect the use of HAART. Preliminary studies support the notion that HAART may prevent or slow the progression of HIVAN to ESRD (21). Therefore, our findings also suggest the possibility that HAART therapy may not be effectively prescribed among the subgroup of HIV-infected ESRD patients. This could be due to underprescription, noncompliance, and/or ineffective prescription of HAART in this group. In support of this possibility, only 33% of cohort patients initiating dialysis during the HAART era were receiving HAART at dialysis initiation, and mean CD4 count at initiation of dialysis — a strong overall predictor of mortality in this cohort — was no different among patients who initiated dialysis during versus before the HAART era. Interestingly, the aforementioned associations of African-American race and injection drug use with mortality among HIV patients may be in part accounted for by a lower prevalence of HAART use in these groups (17). Along similar lines, a recent study showed that HCV co-infected patients were less likely to receive HAART than HIV patients without HCV co-infection, possibly due to concern by prescribing physicians of HAART-related hepatotoxicity (18,19). In addition, there may be differences in HAART response rates and drug pharmacokinetics (20) among ESRD and pre-ESRD patients versus those without ESRD.

Multivariate analysis showed that traditional predictors of improved survival in HIV-infected patients and in ESRD pa-

### Table 4. Median survival after an AIDS-opportunistic illness (AIDS-OI) diagnosis by year of AIDS-OI, San Francisco, as of November 2002

<table>
<thead>
<tr>
<th>Year of Initial AIDS-OI</th>
<th>Total Number of Cases</th>
<th>Median Survival (mo)</th>
<th>CD4 at AIDS-OI (Within 3 mo of OI diagnosis)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>CD4 &lt; 200</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>1992</td>
<td>1806</td>
<td>17</td>
<td>988</td>
</tr>
<tr>
<td>1993</td>
<td>1539</td>
<td>18</td>
<td>861</td>
</tr>
<tr>
<td>1994</td>
<td>1591</td>
<td>16</td>
<td>938</td>
</tr>
<tr>
<td>1995</td>
<td>1336</td>
<td>30</td>
<td>762</td>
</tr>
<tr>
<td>1996</td>
<td>879</td>
<td>81</td>
<td>490</td>
</tr>
<tr>
<td>1997b</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Personal communication: Hsu L, San Francisco Department of Public Health, 2002.

b Median survival cannot be determined due to censored data.

Note: Number of cases may not add up to the total number of cases due to missing data.

### Table 5. Comparison of median survival in HIV-infected patients

<table>
<thead>
<tr>
<th>Study Authors and Location</th>
<th>n</th>
<th>Time Period</th>
<th>Median Survival (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rao et al., HIV-infected ESRD patients in New York City (10)</td>
<td>61</td>
<td>1982–1986</td>
<td>1.4</td>
</tr>
<tr>
<td>Kimmel et al., HIV-infected ESRD patients in Washington, DC (30)</td>
<td>31</td>
<td>1984–1992</td>
<td>13</td>
</tr>
<tr>
<td>Tebben et al., HIV-infected ESRD patients in New Haven, CT (31)</td>
<td>39</td>
<td>1987–1992</td>
<td>10</td>
</tr>
<tr>
<td>Dave et al., HIV-infected ESRD patients in NYC (22)</td>
<td>50</td>
<td>1987–1996</td>
<td>11</td>
</tr>
<tr>
<td>HIV-infected ESRD patients in San Francisco</td>
<td>58</td>
<td>1985–1994</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>57</td>
<td>1995–2002</td>
<td>16.1</td>
</tr>
<tr>
<td>USRDS data, HIV-infected ESRD patients (11)</td>
<td>1792</td>
<td>1995–1996</td>
<td>≥12*</td>
</tr>
<tr>
<td></td>
<td>1642</td>
<td>1997–1998</td>
<td>≥24b</td>
</tr>
<tr>
<td>All HIV patients in San Francisco</td>
<td>1591</td>
<td>1994</td>
<td>16</td>
</tr>
<tr>
<td>Survival after AIDS-OI (4)c</td>
<td>879</td>
<td>1996</td>
<td>81</td>
</tr>
</tbody>
</table>

* Estimated median survival, 53% ± 1.2 survival at 12 mo.

b Estimated median survival, 54% ± 1.3 survival at 24 mo.

c Also personal communication: Hsu L, San Francisco Department of Public Health, 2002.
tients are also operative in the group with both HIV infection and ESRD. Consistent with prior studies (22), higher CD4 count was strongly associated with improved survival in HIV-infected patients. In addition, we found that hypoalbuminemia was also strongly associated with death in cohort patients. A 1 g/dl decrease in serum albumin was equivalent to a CD4 count ≤ 200 cells/mm³ in terms of how well it predicted future mortality in this group. This finding is consistent with studies showing an association of hypoalbuminemia with death in both non–HIV-infected ESRD patients (23,24) and HIV-infected patients without ESRD (25,26). It remains unclear exactly how hypoalbuminemia influences patient survival, but malnutrition, inflammation, and coronary artery disease have been implicated (27–29).

A strength of the present analysis is that, unlike studies based on registry data, HIV status was uniformly collected for all patients. Thus trends in patient survival over the study period are unlikely to be biased by differential underreporting of HIV status early in the epidemic. However, a limitation of the present analysis is that we were unable to clearly define the association of HAART use with survival. This was first due to the fact that the retrospective study design did not lend itself to detailed data collection on HAART use. We measured only whether patients were receiving HAART at the initiation of dialysis. More detailed data on virologic response, compliance, and length of treatment before and after initiation of dialysis would have been much more informative. Second, our ability to detect an association of survival with HAART use was also limited by the small size of the sample of patients initiating dialysis during the HAART era. Confidence intervals for the association of HAART use with survival (and other associations tested for this subgroup) were wide, leaving open the possibility that associations with survival that are too weak to be detected in the present analysis may nevertheless exist. Thus, the lack of a statistically significant association of HAART use with improved survival in the present analysis cannot be interpreted to mean that HAART is ineffective in this group.

In conclusion, dramatic improvements in survival have now been documented among HIV-infected patients without ESRD since the mid-1990s, which most certainly reflects the increased use of HAART in this population. However, in a large cohort of HIV-infected ESRD patients followed over 17 yr, we found no improvement in unadjusted survival, no improvement in CD4 count at initiation of dialysis, and only a non-statistically significant trend toward improved survival in adjusted analysis. While poor survival among HIV-infected ESRD and pre-ESRD patients may reflect confounding by factors such as race, injection drug use, and HCV co-infection, it is also likely that nonprescription, noncompliance, and/or lack of efficacy of HAART in this group contribute to continued poor survival. Therefore, research on barriers to the effective use of HAART in HIV-infected dialysis patients, and particularly in the subgroup with low CD4 counts and serum albumin at initiation of dialysis, may offer important opportunities to augment survival.

Acknowledgments

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13. 1993 revised classification system for HIV infection and expanded surveillance case definition for AIDS among adolescents and adults. MMWR Recomm Rep 41: 1–19, 1992


